ENVIRONMENTAL APPROACH OF THE END-OF-LIFE OF BUILDINGS

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Abstract

Due to a worldwide increasing population, the construction sector is key in the international economy. This activeness implies consequences from an environmental point of view. Numerous life cycle assessments (LCA) studies have been made on buildings and pointed out the importance of the impacts caused by the use phase. The development of low energy buildings has been a step forward to decrease these impacts. The environmental burdens associated with the end of life of buildings are low so the interest showed to this particular phase is because it allows closing the loop in the material and good life cycles. Indeed, reclaimed and reused components and recycled materials can bring environmental benefits. To assess these potential benefits, it is essential to know the current practices in terms of demolition and the parameters which have an influence on the final LCA result.

Based on data of a recent demolition site, a partial LCA has been realised that underlines two points. Nowadays, mechanical demolition is commonly used implying fuel consumption then waste management induces waste to be transported to recycling facilities, waste-transfer stations or landfills. The remaining shadow stays on the future of the different materials sorted once they left the station. On this case study chosen, fuel burnt in the machines has the highest contribution to the final impacts. However, this result is not taken as a conclusion but as step to a more complete LCA. The final objective is to assess the consequences in terms of environmental impacts of a change of practices in the demolition process.

Keywords

LCA, end-of-life of buildings, demolition

1. INTRODUCTION

In 2010, the French construction industry has produced 360 millions of tons of waste representing more than 40% of the total waste generated on the territory. Building construction sites which account for 50 millions tons of waste can be divided in three categories: renovation, construction and demolition sites. The study focuses on the latter one which generates about 65% of the waste [1]. Those waste are mostly composed of inert (mainly concrete and bricks) and non dangerous ones like untreated wood, plastics and metals [2]. The environmental impacts of this end of life stage are relatively small even negative sometimes compared to the material production stage or the use phase [3]. However, demolition is a key stage as it permits to reduce the three main impacts that can be attributed to the building sector: depletion of non-renewable natural resources (minerals or fuels), air pollution from manufacturing processes and road transport, and decrease of the pressure on landfill sites [4]. To complete these goals, it seems crucial to adopt the best possible strategy in order to reuse, recycle and increase the valorisation of the different goods and components of the buildings.

Life cycle assessment (LCA) is an environmental tool to assess the impact potentials of a product or a system from the material production to the end of life. Two main approaches can be distinguished: attributionnal and consequential. Attributionnal LCA (ALCA) takes into account the impacts of all the flows inside the studied system whereas consequential LCA (CLCA) focuses on the environmental consequences due to a change in the system. Thus, only processes that are modified by this change are modelled in CLCA.

This LCA tool will be applied to the end of life stage of the buildings. The objective of this work is to realize an ALCA to better understand this system and lay the foundations of a further CLCA which goal will be to evaluate the impact potentials due to a change of practices in the demolition of buildings.

2. METHODOLOGY

2.1 ALCA

The ALCA tool is standardised by norm ISO 14 040 [5] and is divided in 4 phases:

- Goal and scope: in this key step, the objectives and the system studied have to be clearly defined. This is done by detailing the functional unit (reference which explicits and quantifies the service delivered by a product system), the boundaries, the assumptions made and their justification…
- Life cycle inventory (LCI): that second step corresponds to the data collect that is to say creating an inventory of flows (inputs and outputs) including raw materials, energy, emissions to air and water...
- Life cycle impact assessment: flows collected in the previous phase are transformed into potential environmental impacts and represented through a set of indicators.
- Interpretation: based on the different indicators, the results are analyzed to draw conclusions and recommendations in accordance with the objectives defined in the first step.

2.2 Demolition steps

A demolition process can be separated in 6 main steps:

- Preparation of the site: organization of the site, temporary installations (fence), pollution risk assessment…At the same time, a site analysis can be done to discover hidden and potentially dangerous materials and to quantify the materials and components to deal with.
- Decontamination – asbestos removal: as asbestos is considered as a dangerous waste, its removal must be dealt with great care and special equipment
- Removal of the light-work: interior and external works, mechanical and electrical equipment are removed
- Cutting of the structure: depending on the location, the structure, or the knowledge of the company a demolition technique is chosen.
- Waste management: waste from the removal of the light-work or of the cutting has to be taken care of. They can be sent to a landfill site, to a recycling facility, potentially reused in another place or incinerated.
- Reconditioning of the site: the foundations can be embanked, the temporary installations are uninstalled.

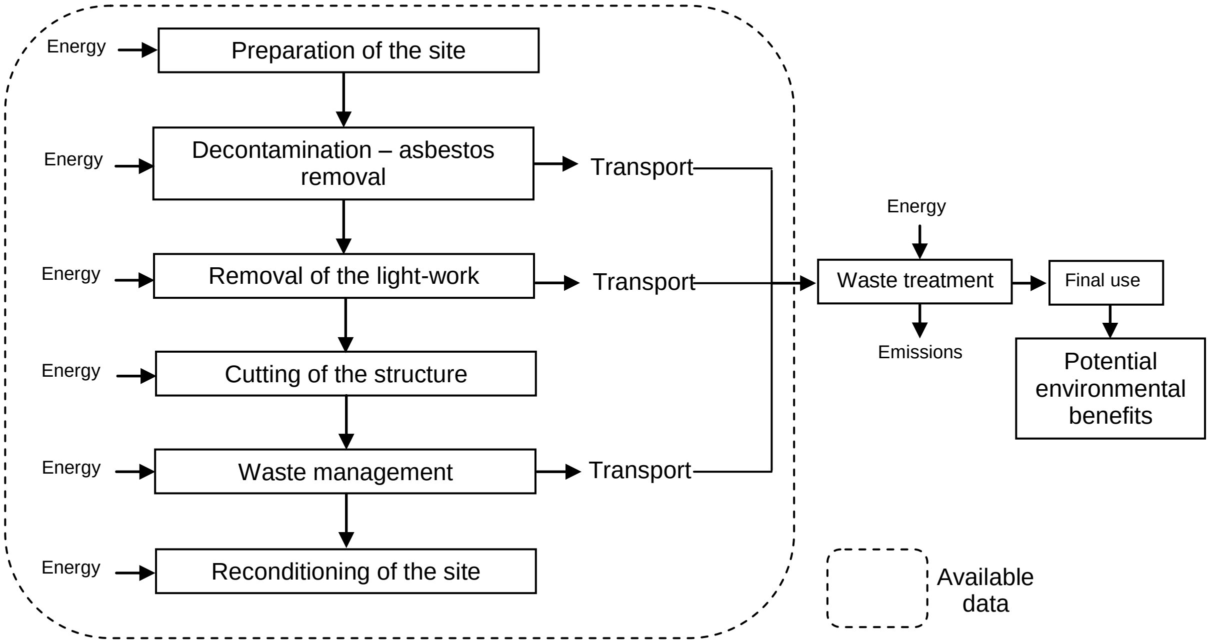

Figure 1: Main steps of the end of life building management [2]

Figure 1 shows two aspects that are needed to correctly model the end of life stage of a building. The first one is energy. Indeed, diesel is burnt in machines to complete the demolition so it is essential to have an idea of how much fuel has been used during the all process. The second aspect deals with transport: it is important to know where and how far waste goes.

3. RESULTS AND DISCUSSIONS

Thanks to the EPFIF (Etablissement Public Foncier d'Ile de France) which takes care of demolition in Paris and its surroundings, we had access to data about some of their construction site. One of those took place in 2012 in the city of Brou-sur-Chantereine (77) and information about the consumption of the machines and the destination of the different waste flows were available and are summed up in table 1:

Table 1: Waste flows of the Brou demolition site

Waste flows	Quantity (tons)	Destination	Distance (km)
Masonry	100	Recycling facility	169
Reinforced concrete	50	Recycling facility	169
Timber	6,54	Recycling facility	14
Plaster	11,76	Landfill	217
Metals	1	Recycling facility	169
Mixed inert waste	17,6	Landfill	217
Asbestos	2,5	Landfill	227

Being the only data available, these material and transport flow were inputted in a LCA software called SimaPro to assess the environmental impacts as a first approximation. The results are shown in figure 2:

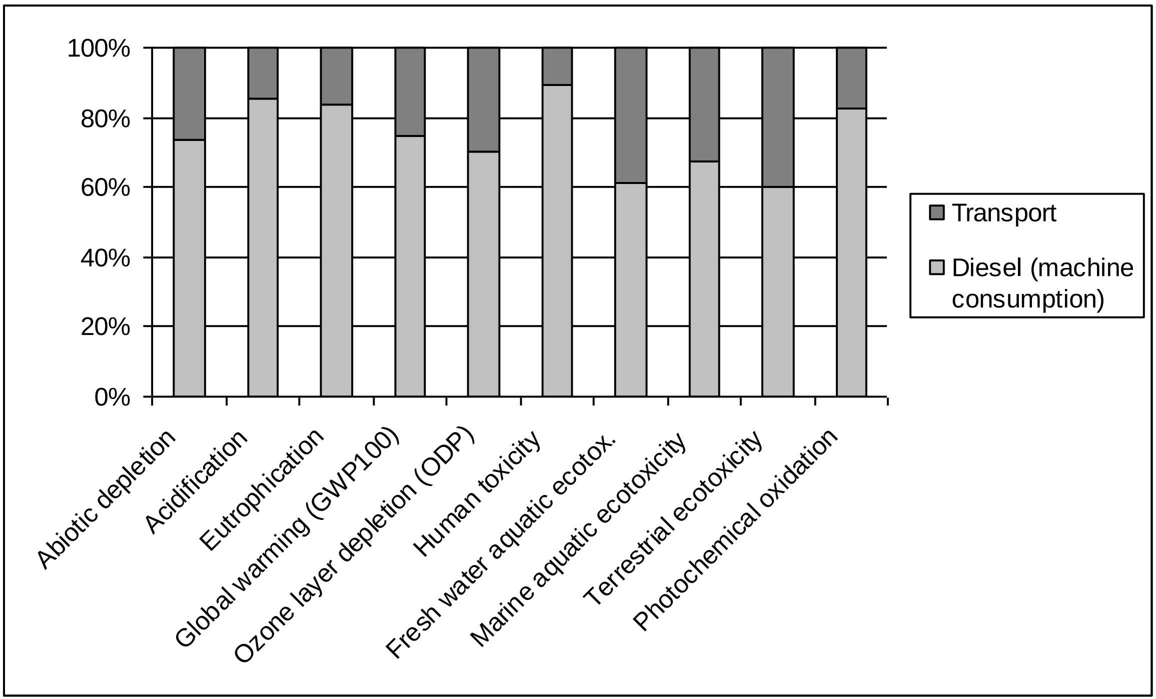

Figure 2: environmental impacts of the Brou demolition site

In this particular example, the energy used during the process has the highest contribution to environmental impacts in every indicator of the chosen method. This simple model underlines two recommendations to decrease the impacts of this phase: optimizing the transport distance of the reclaimed components and waste flows and to reduce the quantity of fuel used during the demolition.

One parameter has been offset of this modelling because of a lack of information: the possible reuse, recycling or incineration of some components or materials. For instance, in a LCA study, the incineration of timber with energy recovery should be accounted for. One possible way of doing it, is to consider that the energy recovered avoids the production of more natural gas and consequently avoids the impacts linked to this production. Likewise, the recycling or the reuse of a metal beam should induce the avoiding of virgin metal production. That’s the reason why it is important to precisely know how each material and component is dealt with after the demolition.

The demolition of each building is different depending on its characteristics (structure, materials, height…), its localisation, the time and economic constraints. However, in a short term perspective, we would like to increase our knowledge about the waste management and the possibilities of reuse in order to achieve a more complete ALCA. Based on these ALCA, the next step will be to switch to the CLCA to assess the environmental consequences of a more selective demolition especially during the light work removal.

REFERENCES

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En raison d'une population mondiale toujours grandissante, le secteur de construction a une contribution non négligeable dans les impacts environnementaux. Les différentes études d'Analyse de Cycle de Vie (ACV) menées sur les bâtiments ont montré l'importance de la production des matériaux et de la phase d'usage sur ces impacts. Notre intérêt s'est pourtant porté sur la fin de vie des bâtiments malgré la faible contribution de cette étape en raison de son importance dans une démarche éco-conceptive. En effet, la valorisation, le recyclage et la réutilisation d'un maximum de composants en fin de vie peuvent entraîner de potentiels bénéfices environnementaux.

L'objectif de cette étude est de réaliser une première ACV d'un chantier de démolition afin d'augmenter les connaissances sur cette phase et déterminer les paramètres à connaître. Ce premier bilan permettra de réaliser une ACV conséquentielle pour estimer les bénéfices possibles d'un changement de pratiques dans la démolition des bâtiments et dans les traitements des déchets.

La démolition d'un édifice peut être décomposée en 6 étapes comme le montre la figure 1 suivie d'une phase de gestion des déchets.

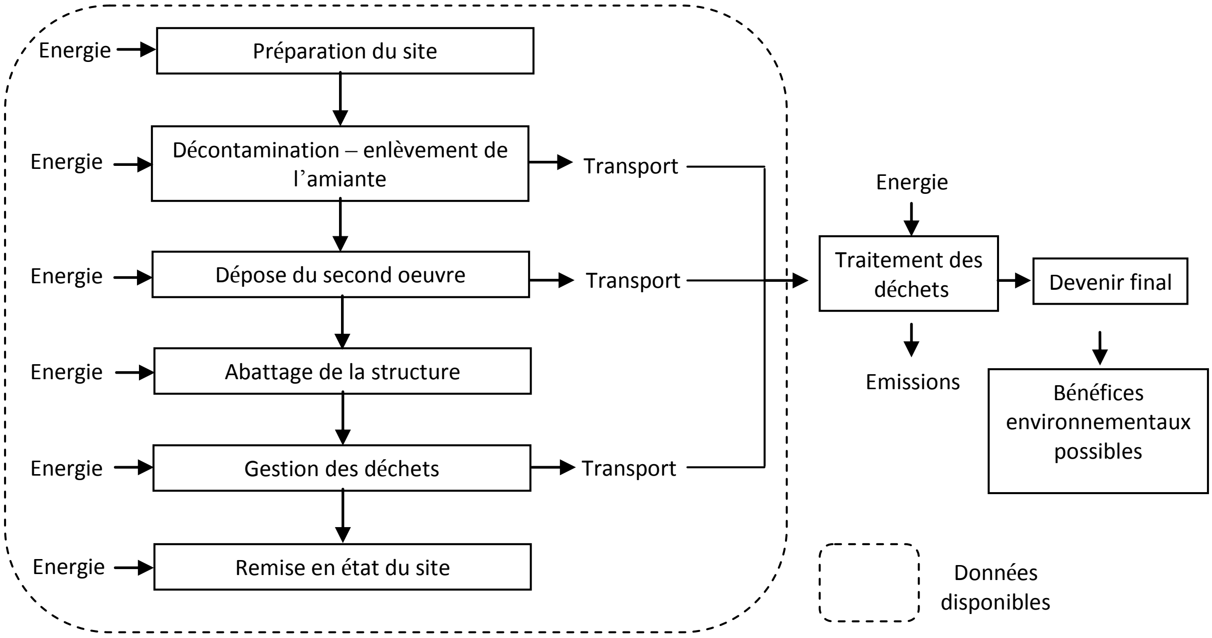

Figure 1: Les différentes étapes de la gestion de la fin de vie des bâtiments [2]

Grâce à l'EPFIF (Etablissement Public Foncier d'Ile de France) qui est responsable de démolitions dans Paris et sa banlieue nous avons pu mener une première étude. Celle-ci prenait en compte la consommation des engins de chantiers et les distances de transport des différents flux de déchets qui étaient les seules informations disponibles.

Ce simple modèle souligne le besoin de limiter la quantité de diesel utilisé ainsi que d'optimiser les distances de transport. Cependant, un paramètre important n'a pour l'instant pu être pris en compte : le devenir final des déchets après être passés par la plateforme de tri et de recyclage. Ainsi, la réutilisation d'éléments et de matériaux ou bien le recyclage peuvent entraîner des bénéfices environnementaux qu'il faudra prendre en compte dans les études à venir. Cette ACV attributionnelle, complétée par plus d'informations sur la gestion des déchets permettra de débuter une ACV conséquentielle pour estimer les bénéfices potentielles d'un changement de pratiques dans la gestion de la fin de vie des bâtiments.